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COMPARISON OF COSTS FOR ALTERNATIVE MIXED LOW-LEVEL WASTE TREATMENT SYSTEMS

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Total life cycle costs (TLCCs), including disposal costs, of thermal, nonthermal and enhanced nonthermal systems were evaluated to guide future research and development programs for the treatment of mixed low-level waste (MLLW) consisting of RCRA hazardous and low-level radioactive wastes. In these studies, nonthermal systems are defined as those systems that process waste at temperatures less than 350°C. Preconceptual designs and costs were developed for thirty systems with a capacity (2927 lbs/hr) to treat the DOE MLLW stored inventory (approximately 236 million pounds) in 20 years in a single, centralized facility. The same waste throughput and profile were used for all systems to allow a comparison of the results of the system studies. A limited comparison of the studies' results is presented in this paper. Sensitivity of treatment costs with respect to treatment capacity, number of treatment facilities, and system availability were also determined.

The major cost element is operations and maintenance (O&M), which is 50 to 60% of the TLCC for both thermal and nonthermal systems. Energy costs constitute a small fraction (<1%) of the TLCCs. Equipment cost is only 3 to 5% of the treatment cost (i.e., TLCCs without disposal) indicating that process selection and R&D funding should promote improved performance, reliability, and technical risk to minimize operations and maintenance labor rather than be based on the capital cost of the technology. Evaluation of subsystem costs demonstrate that receiving and preparation is the highest cost subsystem at about 25 to 30% of the TLCC for both thermal and nonthermal systems.

These studies found no cost incentives to use nonthermal or hybrid (combined nonthermal treatment with stabilization by vitrification) systems in place of thermal systems. However, there may be other incentives including fewer air emissions and less local objection to a treatment facility. Building multiple treatment facilities to treat the same total mass of waste as a single facility would increase the total treatment cost significantly, and improved system availability decreases unit treatment costs by 17% to 30%.

INTRODUCTION

From 1993 to 1996, the Department of Energy, Environmental Management, Office of Science and Technology (OST), has sponsored a series of systems analyses to guide its future research and development (R&D) programs for the treatment of mixed low-level waste (MLLW) consisting of RCRA hazardous and low-level radioactive waste. The technologies were evaluated as part of a total treatment system capable of processing MLLW to meet the Environmental Protection Agency's (EPA's) Land Disposal Restrictions (LDRs). The first study, Integrated Thermal Treatment Systems (ITTS) - Phase 1, evaluated relatively mature thermal treatment technologies (Reference 1). This study was extended to Phase 2 in which more innovative thermal treatment technologies were evaluated (Reference 2). As a result of a technical review (Reference 3) of the ITTS studies, a similar study of nonthermal systems, known as the Integrated Nonthermal Treatment Systems (INTS) study was conducted (Reference 4). In the INTS study, nonthermal systems are defined as those systems that process waste at temperatures less than 350°C. This temperature was chosen to minimize volatilization of heavy metals and radionuclides, and production of dioxins and furans in the offgas.

Because of the growing importance of stakeholder involvement in DOE decision making, as well as recommendations from the ITTS peer review (Reference 3), public involvement in the INTS study was established through a working group of 20 tribal and stakeholder representatives (Native Americans, state and local government representatives, citizens, environmental groups, and personnel from private

companies). This Tribal and Stakeholder Working Group (TSWG) was organized to provide input to the INTS studies, and identify principles against which the systems should be designed and evaluated. At the TSWG suggestion, one of the nonthermal systems was selected for comparison of performance and cost by replacing nonthermal grout stabilization with vitrification. This resulted in the Enhanced Nonthermal Treatment Systems (ENTS) study that included hybrid systems consisting of nonthermal treatment and thermal metal recovery and waste stabilization technologies (Reference 5). The ENTS study also investigated the cost impact of replacing grout with other nonthermal stabilization materials and increasing the reaction rate of the organic waste treatment process.

In all, preconceptual designs were developed for thirty systems to process the same mixture of MLLW at a rate of 2927 lbs/hr (1328 kg/hr) in a single, centralized facility operating for 40 weeks per year at 60% availability (i.e., 4032 hrs/yr). This processing capacity could treat the DOE MLLW stored inventory (approximately 236 million pounds or 107 million kilograms) in 20 years. The DOE inventory of MLLW from all DOE sites (Reference 6) was used as the starting point for the 1993 study, and from this inventory an average waste profile was developed for the ITTS study (Reference 7). This waste profile was retained though all the subsequent studies to allow a direct comparison of systems even though estimates of the inventory volume and content have changed as improved estimates have been developed by the sites (Reference 8). This waste profile consisted of a wide range of combustible and non-combustible materials such as paper, plastics, metals, concrete, soils, sludges, etc.

TECHNICAL APPROACH

The treatment systems were conceptually designed to treat MLLW in compliance with RCRA and to produce final waste forms that would meet DOE performance assessment requirements at a disposal site. The treatment facility designs complied with DOE requirements for facilities handling radioactive material and EPA requirements for RCRA treatment facilities. They accommodated the treatment of wastes containing alpha emitting radionuclides so that triple containment barriers were included in parts of the facility. Remote handling was assumed for high risk areas such as waste sorting. The air pollution control (APC) systems were designed to lower emissions below the requirements of the Clean Air Act by a factor of ten. Mass and energy balances were developed using the ASPEN Plus© computer code to determine the energy requirements, amount of process reagents, quantities of gaseous and liquid effluents, and the amount of stabilized final waste forms going to disposal.

Life cycle costs (in present year dollars) were estimated assuming a government-owned, contractor-operated (GOCO) facility, and were based on preconceptual designs, detailed equipment lists and equipment layouts, and facility isometric drawings. While these analyses were being performed on the basis of a fixed set of assumptions, questions arose regarding the sensitivity of the costs to these assumptions. Another study (Reference 9) evaluated the sensitivity of system life cycle costs with respect to cost element and subsystem, facility capacity and availability, operating life, contingency allowance, and disposal costs.

SYSTEM DESCRIPTIONS

System concepts were developed using combinations of technologies commonly used in hazardous waste treatment and innovative technologies being developed by DOE laboratories and the private sector. The technologies ranged from very mature processes, such as incineration, to processes in development such as acid digestion. In all, 20 thermal systems, 5 nonthermal systems, and 5 enhanced nonthermal systems were studied. A limited comparison of the studies' results is presented – five thermal systems representative of the ITTS study, the five nonthermal systems evaluated in the INTS study, and four of the enhanced nonthermal systems. The thermal systems were selected to represent a combination of mature and innovative technologies. The systems are briefly described below; detailed descriptions, flowsheets, and other related information are available in References 1, 2, 4, and 5.

Thermal Systems

1. Rotary kiln with vitrification and air for combustion (System A-1).
2. Slagging rotary kiln with air for combustion (System A-7).
3. Rotary kiln with grout stabilization and air for combustion (System A-8).
4. Plasma furnace with air for combustion (System C-1).
5. Steam reforming with vitrification (System H-1).

Nonthermal Systems

1. Mediated electrochemical oxidation for organic destruction, thermal desorption of soil and process residue, primary stabilization of treated sludge in polymer, and primary stabilization of treated soil and untreated debris in grout (System NT-1).
2. Catalyzed wet oxidation for organic destruction, thermal desorption of soils, process residue and debris, primary stabilization of treated sludge in polymer, and primary stabilization of treated soil and treated debris in grout (System NT-2).
3. Mediated electrochemical oxidation for organic destruction, aqueous washing of soils, process residue and debris, primary stabilization of treated sludge in polymer, and primary stabilization of treated soil and treated debris in grout (System NT-3).
4. Acid digestion for destruction of organics and combustible debris, aqueous washing of soils and noncombustible debris, thermal desorption of process residue, and primary stabilization of treated waste in phosphate bonded ceramic (System NT-4).
5. Catalyzed wet oxidation for destruction of organics and combustible debris, aqueous washing of soils and noncombustible debris, thermal desorption of process residue, primary stabilization of treated sludge in polymer, and primary stabilization of treated soil and treated debris in grout (System NT-5).

Enhanced Nonthermal Systems

1. This is a hybrid thermal/nonthermal system that is the same as System NT-5 except treated soil and debris are vitrified instead of grouted; treated inorganic sludge continues to be stabilized in polymer (System ENTS-1).
2. This is a hybrid thermal/nonthermal system that is the same as System ENTS-1 except the thermal desorber is eliminated, and untreated inorganic sludge is vitrified (System ENTS-2).
3. This is a nonthermal system that is the same as System NT-5 except all treated inorganic sludge, soil and debris are stabilized in polymer (System ENTS-3).
4. This is a nonthermal system identical to System NT-5 except the reaction rate of the chemical oxidation process is assumed to be increased by a factor of ten (System ENTS-5).

In all systems, metal is separated from the other waste matrices. Surface contaminated metal is decontaminated in all systems for recycle within the DOE complex. In thermal systems (except for System A-7 in which metal is melted with the slag for disposal) and hybrid systems, metal with entrained contamination is melted into ingots for recycle within the DOE complex, and in nonthermal systems metal with entrained contamination is stabilized as debris. Primary stabilization of treated waste is by vitrification, grout, phosphate bonded ceramic, or polymer depending on the system, and secondary stabilization of salts and other secondary wastes is in polymer.

Thermal systems are relatively simple in that primary treatment uses one main treatment process and the organic waste and organic contaminants on the inorganic waste are destroyed in essentially one operation. In contrast, nonthermal systems require removal of the organic contaminants from the inorganic matrices to facilitate destruction by chemical oxidation. Removal is accomplished by vacuum thermal desorption or several washing processes, depending on the characteristics of the solid matrices. This greater complexity of nonthermal systems results in higher life cycle costs.

System NT-5 was chosen as the basis for the enhanced nonthermal study because catalyzed wet oxidation can treat combustible debris, remove it from the waste stream, and decrease the stabilized waste volume. Detailed comparisons of various system parameters are presented in Reference 10. This paper summarizes only the results of the cost comparisons in Reference 10, and the cost sensitivity studies in Reference 9.

LIFE-CYCLE COSTS

Total life cycle costs (TLCC) were estimated for all major cost components such as technology development and demonstration, pre-construction project costs including design and permitting, construction and equipment, operations and maintenance, decontamination and decommissioning (D&D), and disposal. Disposal is assumed to be in an engineered RCRA facility with a disposal cost of $243 per cubic foot ($8580/m^3). The waste was assumed to be disposed on site and no costs associated with transportation to or from the facility were included. Subsequent studies have shown the transportation costs would be small compared to the TLCC and could be ignored without impacting the conclusions. In the following discussion TLCC refers to total life cycle cost including disposal, whereas the term "treatment cost" refers to total life cycle cost without disposal.

Major cost elements of the TLCC including capital, operating and maintenance (O&M) and disposal costs are shown in Table I. In addition to these cost elements, total life cycle costs include test and demonstration which ranges from $100 million for systems with relatively mature technologies to $175M for systems with immature technologies, pre-construction which ranges from $100 to $145 million, and D&D costs ranging from $50 to $85 million. These costs are in constant dollars and are estimated to be accurate within ±30%. Although inclusion of the time value of money may change the absolute values, it would make little difference in the relative costs and would not impact the conclusions (Reference 9).

For thermal systems, the TLCC ranges from $2.2 to $2.8 billion, from $3.7 to $3.9 billion for nonthermal systems, and $3.4 to $3.8 billion for hybrid systems. The unit treatment costs, excluding disposal, are $8 to $9/lb ($18 to $20/kg) for thermal systems producing a glass/ceramic final waste form, $12 to $14/lb ($26 to $31/kg) for nonthermal systems producing a grout or phosphate bonded ceramic final waste form, and $13 to $14/lb ($29 to $31/kg) for hybrid systems producing a glass/ceramic final waste form. Disposal costs add approximately $1/lb ($2/kg) for systems that produce a glass/ceramic final waste form, and $3/lb ($7/kg) for systems that use nonthermal primary stabilization, with the attendant polymer for secondary waste for both systems.

The TLCC costs of nonthermal and hybrid systems averaged 40 to 60% higher than thermal systems. These higher costs of nonthermal and hybrid systems are due to their greater complexity in the form of more unit operations which require more operating personnel and maintenance activities, and the greater volume of stabilized waste sent to disposal. These costs also reflect the lower maturity and, therefore, higher research and development costs associated with nonthermal treatment. Nonthermal systems NT-4 and NT-5 have the highest capital cost of nonthermal systems due to the added equipment for destruction of soft debris. The hybrid systems have a complexity similar to that of nonthermal systems but with the added cost of a vitrifier.

Place Table I here.

Increasing the reaction rate of the chemical oxidation process ten fold (ENTS-5) decreases the TLCC by 1%. The increased reaction rate allows the soft debris and organic liquids and sludges to be treated in the same vessel and in only one shift. However, the savings in processing equipment and operating personnel is offset by the increased cost of material handling equipment, maintenance personnel, and ancillary systems required to maintain the higher rate of waste feed to keep pace with the increased reaction rate.

No significant differences in treatment costs occur among the thermal treatment technologies. Likewise, no significant differences in treatment costs occur among the nonthermal technologies. The major differences in TLCC within the categories of thermal and nonthermal systems are due to the differences in the volume of the final waste form which impacts disposal costs. Disposal costs are about 20% of the TLCC for nonthermal systems, and 11% for systems using vitrification for stabilization. Nonthermal stabilization produces significantly higher volumes of final waste forms, and therefore higher disposal costs, than thermal stabilization methods. System A-8 uses grout for stabilization and has a disposal cost 2 to 3 times that of the thermal systems that produce a glass/ceramic waste form. Systems NT-4 and NT-5 treat combustible debris in an oxidizing solution and decrease the amount of waste sent to stabilization; therefore, their disposal costs are slightly lower than the other nonthermal systems. Although System ENTS-1 replaces grout in System NT-5 with vitrification, disposal costs are still high because treated process residue (which makes up 34% of the incoming waste) is stabilized in polyethylene along with the smaller amount of secondary waste so that the final waste form volume is much higher than a vitrified waste. In System ENTS-2 the process residue (or inorganic sludge) is vitrified, thereby producing a final waste form volume and disposal cost similar to that of the thermal systems.

The major cost element is O&M, which is 50 to 60% of the TLCCs for both thermal and nonthermal systems, followed by capital costs for systems using a vitrifier, and then by disposal costs. Average nonthermal O&M costs are 50% higher than the thermal O&M costs with labor costs the major driver. Energy costs constitute a small fraction (<1%) of the TLCCs. Capital costs (equipment and construction) range from 20 to 30% of the treatment costs whereas equipment alone is only 3 to 5% of the treatment costs. Thus, a 50% decrease in equipment cost would produce only a 2 to 3% decrease in treatment cost; however, a 50% decrease in O&M costs would produce a 35% decrease in treatment cost. This indicates that process selection and R&D funding should promote improved performance, reliability, and technical risk to minimize operations and maintenance labor rather than be based on the capital cost of the technology.

Evaluation of subsystem costs demonstrate that receiving and preparation, which is about 25 to 30% of the TLCC for both thermal and nonthermal systems, is the highest cost subsystem. This subsystem includes receiving, characterization, sorting, and size reduction and has the highest capital cost and requires the most labor of all the subsystems. Receiving and preparation costs for nonthermal and hybrid systems are about 40% higher than for thermal systems due to the increased need for sorting and routing to the appropriate treatment process. Systems with higher volumes of waste sent to disposal also require more labor in the certification and shipping subsystem. The cost of the air pollution control (APC) subsystem is a small fraction (from 2% to 5%) of the TLCC for both the nonthermal and thermal treatment systems.

Several conclusions may be drawn from these studies: (1) significant savings ($400 million) can be achieved in thermal systems by using vitrification of ash and other residue instead of grout, and an additional $200 million may be saved by producing a disposable slag in a single operation (Systems A-7 and C-1); (2) R&D to decrease the equipment and personnel needs for front-end handling may produce a significant payback - a 50% decrease in front-end handling cost will produce a 16% decrease in TLCC; (3) equipment costs are not the major cost element, so process selection should be based on performance, reliability, and technical risk rather than technology cost; (4) APC costs are a very small fraction of the TLCC and the best APC system available should be used to minimize local concerns and potential permitting problems; (5) there is no cost incentive to use nonthermal or hybrid systems; (6) nonthermal and hybrid systems produce less offgas than do thermal systems (References 10 and 11) and a vitrified waste form is more stable than nonthermal waste forms so there may be reasons other than cost for using such systems; and (7) there appears to be no cost incentive for committing R&D funds to increase the reaction rate of chemical oxidation processes.

COST SENSITIVITY TO ASSUMPTIONS

Sensitivity analyses were performed to determine economies of scale, effect of improving system availability, and effect of using regional treatment facilities. These cases were compared to thermal system A-1 which was used as a baseline system with a treatment cost of $2,167 million. The method used to analyze the impact on treatment cost for differing facility capacities is based on exponential scaling of the ITTS cost estimates (Reference 12). For example, if the cost of a treatment facility component of capacity q_1 is C_1, then the cost of a similar treatment facility component of capacity q_2 is given by $C_2=C_1(q_2/q_1)^n$ where n is the scaling factor. The scaling factor, n, is varied from 0 to 1, where scaling factors closer to 0 result in a cost, C_2, that is independent of the size of the facility, and scaling factors closer to 1 results in a cost directly proportional to the size of the facility. A scaling factor between 0.6 and 0.7 is typically used in industry for a processing plant. To bound any uncertainty associated with the selection of a specific scaling factor, the treatment costs have been calculated and are presented for a range of scaling factors.

Doubled Capacity: This case compares the treatment cost of a facility sized for twice the capacity of the baseline system to the cost of the baseline system. Doubling capacity implies doubling the throughput rate; therefore, the same quantity of waste can be treated in half the original time (e.g., the operating period is reduced from 20 to 10 years). Alternatively, doubling the capacity of the facility would allow twice the original input waste, or 476 millions pounds (216 million kg), to be treated over a 20 year operating life. This additional waste may be generated from production operations, or from remediation and decontamination and decommissioning operations.

Doubling the facility capacity and reducing the operating period from 20 to 10 years increases the costs for construction, pre-operation, and D&D but decreases the O&M costs. When using a 0.58 scaling factor, the overall treatment cost for operating 10 years is approximately the same as operating 20 years. Thus, if costs are scaled using a factor less than 0.58 then the treatment costs for operating for ten years is less than the cost for operating 20 years as shown in Figure 1. Alternatively, if the capacity is doubled and twice the baseline waste input is treated over 20 years, the treatment cost is greater than the baseline but the unit cost decreases from the baseline unit cost of $9.18/lb ($20.24/kg). Assuming a scaling factor of 0.5 to account for the higher percentage of fixed costs for construction and operation of a GOCO treatment facility, and doubling the capacity, the unit cost for a 10 year operation is $8.72/lb ($19.22/kg) and the unit cost for a 20 year operation with twice the baseline amount of waste treated is $6.40/lb ($14.11/kg).

Place Fig. 1 here.

Multiple Facilities: The first case assumes two treatment facilities, one located in the Western U. S., and one in the Eastern U. S. The target waste stream for each facility is assumed to be representative of the entire inventory; therefore, the two facilities are assumed to be duplicated in design, demonstration and testing. For this reason, these costs are not duplicated in determining the cost of the second facility. Based on the proportion of waste stored at DOE sites located in the East and the West, the 236 million pounds of input waste is split, 66% to be treated at the eastern location and 34% at the western location. As shown in Figure 1, the cost of two facilities is greater than the cost of a single baseline facility regardless of the scaling factor. This analysis indicates that constructing and operating two treatment facilities will result in a 14% to 69% increase in treatment costs over the baseline with scaling factors ranging from 0.8 to 0.2. The waste distribution and cost of each facility are shown in Table II for a scaling factor of 0.5.

The second case considers five regional treatment facilities located at the larger DOE sites where over 176,600 ft^3 (5,000 m^3) of MLLW are stored (i.e., Hanford, Idaho National Engineering Laboratory, Rocky Flats Plant, Savannah River Site, and Oak Ridge National Laboratory). For this regional option the waste stream inventory for treatment at each of the facilities will not be representative of the entire inventory; therefore, the design, demonstration and testing phase will be required at all sites. Again, the 236 million pounds of input waste was apportioned among the five facilities as shown in Table II. The total treatment cost as a function of scaling factor is shown in Figure 1. Depending on the scaling factor, operating five treatment facilities results in a 46% to 244% increase in total treatment cost when compared to the baseline. This increase translates to a range of unit treatment costs from \$13.45/lb (\$29.65/kg) to \$31.57/lb (\$69.60/kg) compared to \$9.18/lb (\$20.24/kg) for the baseline system. Total treatment costs for each facility, assuming a scaling factor of 0.5, are shown in Table II.

Place Table II here.

These results demonstrate that larger facilities can treat greater quantities of waste at a lower cost per pound than smaller facilities, and that total treatment costs for a single facility is less than treatment costs for multiple facilities.

Increased Availability: Another means for reducing the operating period or increasing the volume of waste treated is to increase the availability of the plant for treatment (i.e., increase the operating hours of the plant). The integrated treatment system studies are based on 4,032 hours per year (280 days/year x 24 hours/day x 0.60 availability). In comparison, if the treatment facility is functional 325 days at 75% availability, then total operating hours per year are 5,850 hours, a 45% increase. At this rate, the 236 million pounds of input waste could be process in 14 years rather than 20 years resulting in a net decrease in O&M costs of \$373 million, a reduction of \$1.58/lb (\$3.48/kg) of input waste. This assumes the annual labor costs remain constant and material and utility costs increase to treat the increased rate of waste input.

Alternatively, at the original throughput rate of 2927 lbs/hr, 343 million pounds (156 million kg) of waste could be treated over 20 years operating at 5,850 hours/year. The total treatment cost increases to \$2,239 million, but the cost per pound to treat this increased quantity of waste is \$6.53/lb (\$14.40/kg) or \$2.65/lb (\$5.84/kg) less than the baseline unit cost. The decrease in unit cost for an increase in availability is shown in Figure 2.

Delisting: The possibility of delisting certain final waste forms offers the opportunity for additional cost savings. The assumption in the ITTS/INTS studies is that the disposal cost is \$243/ft^3 (\$8580/m^3) based on an average size RCRA-permitted engineered disposal facility using \$67/ft^3 (\$2366/m^3) for receiving and \$176/ft^3 (\$6215/m^3) for engineered disposal (Reference 13). However, if vitrified waste produced in the thermal treatment processes can be delisted for the RCRA constituents, the waste form would be managed and disposed in a manner consistent with the requirements of the Atomic Energy Act of 1954 as implemented by DOE Order 5820.2A, Radioactive Waste Management. Delisting the vitrified final waste form would allow disposal of low-level radioactive waste at an existing shallow land disposal facility, such as the Hanford facility, at a cost of \$40/ft^3 (\$1412/m^3) (Reference 14). Applying the shallow land disposal cost to the volume of slag from the vitrification process (approximately 8 ft^3/hr or 0.23m^3/hr), and the disposal cost of a RCRA engineered disposal facility for the remaining stabilized waste, the total estimated cost of disposal for the systems employing vitrification for stabilization is reduced by as much as \$130 million, or 6% of the TLCC. However, at disposal costs less than \$58/ft^3 grout stabilization becomes more cost effective than vitrification because the cost to dispose of higher volumes of waste becomes less than the capital and operating cost of a vitrifier (Reference 2). Efforts are on-going and planned to refine estimates of final waste form loading and disposal costs. These estimates will be based on varying the input waste parameters (e.g., physical matrix, quantity, etc.) and using cost estimates from existing RCRA Subtitle C facilities.

Place Fig. 2 here.

SUMMARY

Several conclusions may be drawn from the results of these systems studies:

- Significant savings ($400 to $600 million) can be achieved in thermal systems by using vitrification instead of grout.

- A 50% decrease in front-end handling cost and associated characterization can save approximately $400 million in TLCC.

- Improvements in system reliability and on-line operating time can provide savings of approximately $400 million.

- Delisting vitrified waste can save approximately $130 million.

- No cost incentive exists to use nonthermal or hybrid systems in place of thermal systems. However, there may be other incentives including fewer air emissions and less local objection to a treatment facility.

- Capital costs are approximately 20% of the TLCC and funds should be spent on the best equipment available to improve reliability and system availability, and decrease O&M costs.

- Combining vitrification with nonthermal treatment makes disposal cost for hybrid systems about equal to thermal. However, reducing treatment costs by 35% ($900 million) is necessary to make hybrid systems economically competitive.

- The effect of changes in system capacity on estimates of treatment cost depends on the scaling factor used.

- Multiple treatment facilities increases the total treatment cost significantly.

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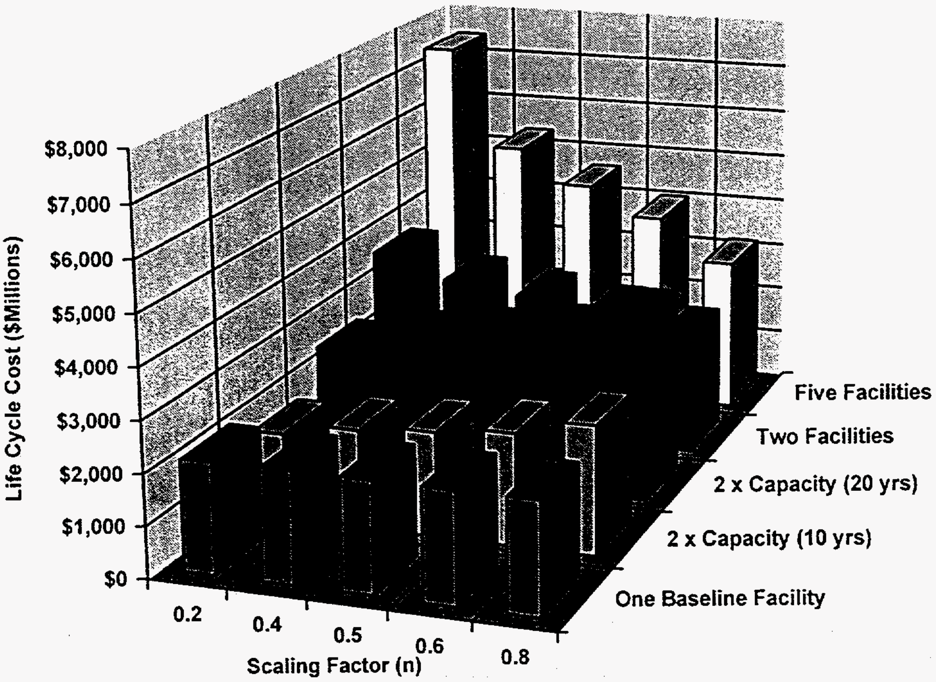

Figure 1. Treatment Cost Sensitivity to Scaling Factors.

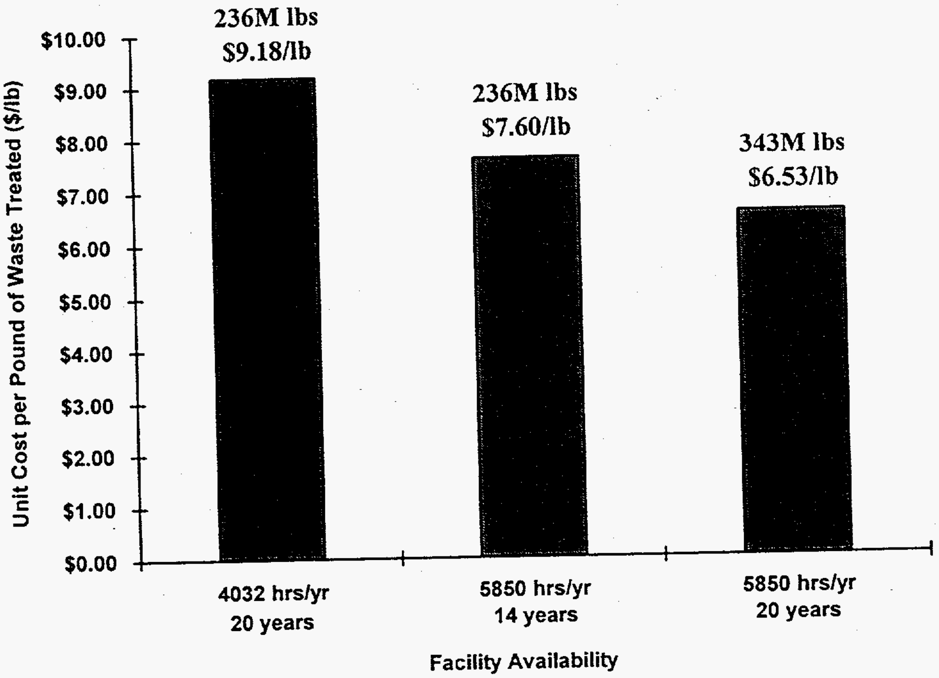

Figure 2. Sensitivity to System Availability

Table I. Comparison of Total Life Cycle Costs ($Millions)

System	Capital Cost	O&M Costs	Treatment Cost*	Unit Treatment Cost ($/lb)	Disposal Cost @ $\$243/\text{ft}^3$	TLCC
A-1	$554	$1,362	$2,167	$9.18[+]	$266	$2,433
A-7	$474	$1,227	$1,936	$8.20[+]	$284	$2,220
A-8	$514	$1,463	$2,229	$9.44	$610	$2,839
C-1	$459	$1,283	$1,981	$8.39[+]	$259	$2,240
H-1	$588	$1,390	$2,193	$9.29[+]	$266	$2,459
NT-1	$600	$1,950	$2,889	$12.24	$833	$3,722
NT-2	$561	$1,930	$2,831	$12.00	$827	$3,658
NT-3	$632	$2,005	$2,992	$12.68	$799	$3,791
NT-4	$673	$2,040	$3,140	$13.31	$737	$3,877
NT-5	$668	$2,058	$3,110	$13.18	$707	$3,817
ENTS-1	$795	$2134	$3326	$14.09[+]	$484	$3,810
ENTS-2	$762	$1878	$3001	$12.72[+]	$286	$3,287
ENTS-3	$660	$2147	$3185	$13.50	$688	$3,873
ENTS-5	$675	$2023	$3078	$13.04	$707	$3,785

*This treatment cost includes capital and O&M costs as well as the costs of test and demonstration, pre-operations, and D&D that are not shown in this table.

[+] Unit treatment costs for systems that use vitrification can be decreased by approximately $1.00/lb ($2.20/kg) by taking credit for contaminated soil used as the glass former for vitrifying ash residue.

Table II. Waste Distribution and Total Treatment Costs for Multiple Facilities (0.5 scaling factor).

System	Capacity (percent)	Capacity (million pounds)	Total Treatment Cost ($Millions)	Unit Treatment Costs ($/lb)
Baseline	100%	236	$2,167	$9.18
Two Regional Facilities				
Eastern Facility	66%	156	$1,781	$11.42
Western Facility	34%	80	$1,208	$15.10
Total Cost			$2,989	$12.66*
Five Regional Facilities				
ORNL	60%	141	$1,703	$12.00
INEL	20%	47	$1,028	$21.80
RFP	10%	24	$758	$32.10
Hanford	5%	12	$568	$47.30
SRS	5%	12	$568	$47.30
Total Cost			$4,625	$19.60*

* Weighted average unit cost